

**IN THE UNITED STATES DISTRICT COURT  
FOR THE NORTHERN DISTRICT OF OKLAHOMA**

STATE OF OKLAHOMA,	)	
	)	
Plaintiff,	)	
	)	
v.	)	Case No. 05-cv-329-GKF(SAJ)
	)	
TYSON FOODS, INC., et al.,	)	
	)	
Defendants.	)	

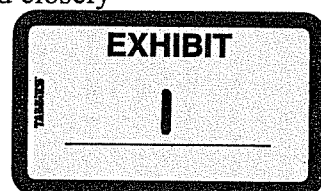
**DECLARATION OF BERNARD ENGEL, PH.D., P.E.**

I, Bernard Engel, Ph.D., P.E., state the following:

1. I have been retained by the Oklahoma Attorney General to provide analysis, advice and opinions on the sources of phosphorus contamination in the Illinois River Watershed, the fate and transport of land applied poultry waste, and poultry waste generation and disposal practices.

2. I previously submitted an Affidavit in this matter that was an exhibit to the Motion for Preliminary Injunction on November 14, 2007. I gave a deposition in this matter regarding the opinions set out in my Affidavit submitted as an exhibit to the Motion for Preliminary Injunction and submitted an Expert Report in this matter on May 22, 2008.

3. I authored all of the materials in my Expert Report with the exception of Report Appendices B and C. As clearly noted at the front of each of these Appendices, Meagan Smith, working under my direction, authored Appendix B of my Report, and Tim Cox, also working under my direction, authored Appendix C of my Report. I relied on the information in Appendix B to draft Section 7.1 of my Report "*P Mass Balance Analysis for the IRW*". I worked closely



with Ms. Smith in determining the analyses to be completed, conducting the analyses, reviewing the results, and preparation of Appendix B including editorial changes. I relied on the information in Appendix C to draft Section 9 of my Report “*Poultry House Density Correlated to Elevated P Levels in Runoff and in Base Flow*”. I worked closely with Drs. Cox and Olsen in determining the analyses to be completed, conducting the analyses, reviewing the results, and preparation of Appendix C. I am capable of and qualified to conduct the work reported in both Appendices B and C. Due to the timeline to complete my Report, I worked with Ms. Smith and Drs. Cox and Olsen to document the evaluations and analyses reported in Appendices B and C.

4. On September 4, 2008, Errata to my Report was submitted to Defendants. My Errata only addresses errors in my Report as explained below. The Errata affects only two of the ten substantive sections of my Report. It made minor changes to Section 1, *Executive Summary/Conclusions* (see discussion below). The Errata also modified Section 10, “*Hydrologic/Water Quality (GLEAMS) modeling of the Illinois River Watershed*” and Appendix D of my Report which relates to the GLEAMS modeling. My Errata did not change my fundamental opinions or conclusions, nor did it introduce substantial amounts of additional and altered information not included in my original Report. My Errata were not intended to bolster, supplement or even replace my expert opinions. Rather it was prepared due to a software coding error that affected the GLEAMS modeling.

5. Phosphorus loading to the Illinois River Watershed (IRW) was evaluated by using the GLEAMS model to calculate phosphorus movement from land to streams. GLEAMS is a hydrologic/water quality model. GLEAMS utilizes hydrologic response units (HRUs) as part of the formula to calculate phosphorous contribution to watershed streams. HRUs are a unique

combination of properties relating to land use, soil types, land management methods and weather conditions. HRUs were created for each such unique combination of such properties within the three major sub watersheds of the IRW. These major sub watersheds are above the stream gauge stations on the Illinois River at Tahlequah, the Baron Fork near Eldon and at Caney Creek just prior to it entering Lake Tenkiller. A mistake was made in the Fortran software code used to run GLEAMS for the HRUs identified within these three major IRW sub watersheds.

6. The number of unique HRUs differs for each of these major sub watersheds. The sub watershed above the Illinois River at Tahlequah is represented with 21 HRUs, while the sub watershed above Baron Fork near Eldon has 20 HRUs, and the sub watershed for Caney Creek has 9 HRUs. Dr. Jeon, who assisted me with the GLEAMS modeling, wrote the Fortran code to run GLEAMS for each HRU within these sub watersheds and the code that summarizes the modeling results (creates output files) for each of these sub watersheds. He also executed the final GLEAMS model runs for my Report. Dr. Jeon executed the GLEAMS model for the Caney Creek sub watershed, and then the code that Dr. Jeon wrote for the Caney Creek sub watershed was copied by Dr. Jeon to directories to run the GLEAMS model for the Illinois River at Tahlequah and Baron Fork near Eldon sub watersheds. The Caney Creek code had the 9 HRUs in it. However, when Dr. Jeon copied the Caney Creek code to run GLEAMS in the other two sub watersheds, he did not update the number of HRUs in the code. Thus, the Caney Creek code with 9 HRUs was used in modeling the Illinois River at Tahlequah and the Baron Fork near Eldon sub watersheds that have 21 and 20 HRUs, respectively. As a result, the GLEAMS model outputs were incorrect since it was not updated between sub watershed runs to reflect the number of HRUs in two of these sub watersheds. Rather, GLEAMS modeling runs reflected only 9

HRUs in the Illinois River at Tahlequah and Baron Fork near Eldon sub watersheds. In preparing my Report I relied on summarized GLEAMS results produced by this code that had the incorrect number of HRUs.

7. As stated above, in addition to running the GLEAMS model, this Fortran code also summarizes the resulting GLEAMS modeling outputs to create modeled phosphorus loads for the three major sub watersheds of the IRW. An additional model was used to route the phosphorus reaching streams under the GLEAMS model and phosphorus from waste water treatment facilities to these three gauging stations in the IRW. Any change in GLEAMS outputs must be propagated through this phosphorus routing model which will then change the phosphorus loads at these three gauging stations.

8. Dr. Jeon had returned to Korea to accept a teaching position at Andong National University in the spring of this year prior to the date my Expert Report was due. Thus, Dr. Jeon was completing his work for me on this project in Korea. The error in the Fortran code was discovered by Dr. Jeon at the time he was asked by me to gather his materials on this project to provide to the Defendants as part of my considered materials production. Upon discovery of the error, Dr. Jeon made the change in the code (to reflect the correct number of HRUs) and reran the GLEAMS model (which revised the GLEAMS modeling results) prior to the production of these materials to the Defendants. Dr. Jeon neglected to inform me of the error he discovered and that he had corrected and had created new GLEAMS modeling runs. Because I was pressed for time to complete my Report at the end of a school year, I did not review Dr. Jeon's materials before they were produced to the Defendants. Because this mistake and correction was not

communicated to me, and because I did not work with the GLEAMS output files, but rather worked with summaries provided by Dr. Jeon, I did not discover the error before I submitted my Report in May, 2008. Therefore, I used GLEAMS modeling results in further modeling, analyses and my Report preparation that were incorrect.

9. Because of these circumstances I was unaware of the error until recently when I was discussing with Dr. Jeon questions the Defendants' modeling experts had concerning the GLEAMS modeling. My Errata corrects this error by using the corrected GLEAMS outputs prepared by Dr. Jeon after he discovered his error. As noted above, the correct GLEAMS files were produced to the Defendants in May. Again, these are the same GLEAMS run files that I used to correct the errors and prepare my Errata.

10. The computer model used in running the GLEAMS model for the HRUs within the sub watersheds was not obsolete or flawed. Rather, a coding error was made in describing the number of HRUs within each sub watershed. As described above, this error was corrected and the corrected GLEAMS results have been used to route phosphorus to the three gauging stations for these sub watersheds in my Errata.

11. I have reviewed the Defendants' Motion and I have also reviewed the First, Second, Third, Fourth and Fifth Declarations of Defendants' retained expert Victor Bierman, Jr. and the First, Second, and Third declarations of Defendants' retained expert Timothy Sullivan. The Defendants' Motion indicates "This errata in effect presents Defendants with an entirely new report ..." This is not correct. Eight of the ten substantive sections of my Report remain

unchanged as do six of seven of the Report's Appendices. The effect of the Errata on my Report can also be demonstrated by the minor changes in the Executive Summary/Conclusions Section of my Report (see redlined attachment). Section 10 and Appendix D are the only other areas of the Report in which changes to figures and tables and numerical values mentioned in the text were made as a result of the error described above. Although many small changes to numbers and graphs in Section 10 of my Report are shown in the Errata, any changes to the routing model inputs which come from the GLEAMS model output will propagate through the routing model to change phosphorus loads at the three gauging stations. Therefore, figures and tables in Section 10 were modified to reflect changes resulting from changes in the routing model inputs. However, only the modeled phosphorus loads to the three gauging stations have changed and were reflected in the Errata as described above. The observed phosphorus loads at these gauging stations for the base period (1997-2006) have not changed.

12. The Defendants' Motion states: "Defendants and their experts will have to essentially start over, trying to match the results revealed in the new report [Errata] against the output of new model runs using the data on which the new report purportedly relies, and begin their new analysis from this starting point ..." This statement is incorrect in several respects. As described above, the majority of the Report is unchanged (8 of 10 Sections and 6 of 7 Appendices are unchanged). Further, the Defendants have had the correct GLEAMS outputs and the supporting files since May. Therefore, the GLEAMS inputs and outputs provided to Defendants in May 2008 have not changed. The change on which the Errata are based is the input data to the routing model spreadsheets that route the phosphorus from the GLEAMS outputs to the gauging stations. These updated spreadsheets with the corrected data inputs were provided to the Defendants with

the Errata. The graphs and tabular data that are included in the Errata are created in these spreadsheets. Therefore, the Defendants only need analyze the updated routing spreadsheets. As indicated above, the GLEAMS computed phosphorus loads to streams have not changed and the Defendants could and should have produced the results that are in the Errata since they have had the correct GLEAMS files since May.

13. The Errata contain no additional tables or charts. Rather, the Errata update the numerical data in existing tables and figures in my Report to reflect the updated phosphorus loading results. The updated Errata figures simply reflect changes in data within the updated tables. The Errata text reflects changes in the text that referenced numerical data from the updated tables and figures. New text and interpretations are not provided in the Errata.

14. The amount of updated material in the Errata is not as extensive as the Defendants' claim. Half of the pages in the Errata are updated Figures that are placed one per page with no additional information on that page. Also, the majority of Figures that were updated in the Errata are presented in two ways (which is the same presentation in the Report). For example, Figures 10.2 and 10.3 present the same information. The only difference between the Figures is that Figure 10.2 includes the annual variation in phosphorus loads in addition to trend lines. Figure 10.3 presents only the trend lines that were presented in Figure 10.2. There are 13 pairs of such Figures.

15. In his Affidavit Dr. Bierman states: “All of the data and analysis in the Engel report is intertwined and interdependent, and we have no way of knowing how (if at all) Dr. Engel's change in one particular number has affected other numbers in his report until we check every change in the errata against his original expert report.” As described above, the changes are confined to the phosphorus routing that is computed in the updated spreadsheets that were provided with the Errata. The Defendants have had the correct GLEAMS files in May, and these were unchanged. The following steps could be used to check the results provided in the Errata:

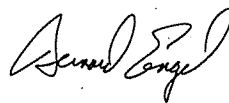
- (1) Remove non-leap year day 366 from GLEAMS outputs (see raw\_data\_8\_29.xls).
- (2) Put GLEAMS summarized outputs from step 1 in phosphorus routing spreadsheets (actual\_and\_no\_litter8\_30.xls, buffer\_no\_litter\_8\_30.xls, historical\_50\_99\_8\_30.xls, p\_model\_8\_29.xls).
- (3) Check routing computations in spreadsheets (actual\_and\_no\_litter8\_30.xls, buffer\_no\_litter\_8\_30.xls, historical\_50\_99\_8\_30.xls).
- (4) Place results from routing computations from spreadsheets in step 3 in spreadsheets to summarize and graph results (baron\_ave\_p\_8\_30.xls, caney\_ave\_p\_8\_30.xls, current\_and\_no\_litter100\_8\_30.xls, graphs\_8\_30.xls, hist\_conc\_8\_31.xls, obs\_p\_vs\_model\_p\_8\_30.xls, summary\_data\_8\_30.xls, tahlequah\_ave\_p\_8\_30.xls).
- (5) Check graphs produced in spreadsheets in step 4 to see that these match graphs in errata.

The time required to conduct the above steps would be approximately ten hours.

16. Dr. Sullivan states in his affidavit "... we will now need to go back to the beginning and reexamine Dr. Engel's entire report again to analyze the changes. ... the scale of the changes means that we must now reevaluate the entire report again ...". As described above, this statement is inaccurate. The Errata do not change anything in sections 2 through 9 and in appendices A-C and E-G of my Report. The minor impact of the changes is highlighted in the redlined Executive Summary/Conclusions section that is attached. Further, the analysis steps to re-produce the Errata changes are described in the paragraph above and do not constitute a requirement to reevaluate the entire Report.

I declare under penalty of perjury, under the laws of the United States of America, that the foregoing is true and correct.

Executed on the 1st day of October, 2008.



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Bernard Engel, Ph.D., P.E.

**Engel Declaration Attachment**

## 1. Executive Summary/Conclusions

### *Illinois River Studies*

Numerous studies have explored phosphorus (P) loads in the Illinois River Watershed (IRW) to the streams and rivers within the watershed and to Lake Tenkiller. Observed data and models indicate nonpoint source pollution is the major contributor to P within the streams and rivers of the IRW and to Lake Tenkiller. Poultry waste application within the IRW to pastures is identified as a substantial contributor to overall P loads within IRW streams and rivers and Lake Tenkiller.

### *Poultry Waste and P Generation*

Each of the defendants' poultry operations within the Illinois River Watershed (IRW) produces a substantial amount of poultry waste and phosphorus. Poultry waste produced within the IRW range between 354,000 and more than 500,000 tons annually. Phosphorus content of the poultry waste ranges from 8.7 million to nearly 10 million pounds annually.

### *Poultry Waste Land Application*

Common practice for poultry waste disposal is land application to pasture and cropped areas. A substantial amount of the defendants' poultry waste and P is land applied within the IRW annually. The poultry waste is applied during the rainy season from late winter through spring.

### *Observed P Loads in the Illinois River Watershed*

The P loads to Lake Tenkiller averaged approximately 505,000 lbs annually between 1997 and 2006. This represents a significant P load to the lake and is much greater per unit area than for other watersheds the region.

### *Point Sources of P in the Illinois River Watershed*

A portion of the P in the IRW reaching Lake Tenkiller is from Waste Water Treatment Plant (WWTP) discharges. P discharges from IRW WWTP have changed over time peaking at slightly more than 204,000 lbs annually in the late 1990s and early 2000s. Beginning in 2003, WWTP P discharges decreased to a little more than 90,000 lbs annually in the IRW due to changes in WWTP technology. The defendants' processing facilities discharge a significant amount of P to WWTPs and thus contribute to point P sources within the IRW.

### *Phosphorus Mass Balance*

A P mass balance for the Illinois River Watershed indicates poultry production is a substantial contributor to P within the Illinois River Watershed. Poultry production within the Illinois River Watershed is currently responsible for more than 76% of P movement into the watershed.

### *P Loads in the IRW Based on Continued Poultry Waste Land Application*

Average annual P loads to water in the Illinois River Watershed attributable to poultry waste application to pastures is calculated at between 432,000 lb to nearly 500,000 lb annually based on poultry P application to the landscape and literature P loss coefficients.

*Poultry House Density Correlated to Elevated P Levels in Runoff and Base Flow*

The analyses of observed P in runoff and in baseflow for 14 small watersheds within the Illinois River Watershed that were sampled in 2005 and 2006 show a strong and statistically significant correlation between P in runoff and in baseflow and poultry house density. Sub-basin poultry house densities are strong predictors of stream total phosphorus concentration showing a cause and effect relationship between poultry house operations and phosphorus concentrations in IRW waters. From these analyses, it is evident that poultry waste is a substantial contributor to P in stream runoff and in the baseflow within streams of the Illinois River Watershed.

*Hydrologic/Water Quality Modeling of Illinois River Watershed*

1. The hydrologic/water quality model was able to accurately model the P loads to IRW rivers and streams and Lake Tenkiller.
2. For continued poultry waste application in the IRW at current levels, modeled P loads to Lake Tenkiller would increase during the first 30 years. For the next 70 years, P loads to Lake Tenkiller would ~~decline slightly and stabilize at levels slightly above current Lake Tenkiller P loads due to P saturation of soils.~~
3. Cessation of poultry waste application in the IRW would decrease P loads to Lake Tenkiller. The reductions in P loads to Lake Tenkiller due to poultry waste land application cessation would be limited to ~~46~~18% during the first 10 years following cessation due to continued P load contributions from historical poultry waste application in the IRW that have elevated soil P. Following poultry waste land application cessation in the IRW, reductions in P loads to Lake Tenkiller would reach 50% by years ~~51-60~~ 31-40.
4. For continued growth in the IRW poultry industry at a rate the same as that between 1982 and 2002, P loads to Lake Tenkiller would increase substantially. Within 40-50 years, P loads to Lake Tenkiller would ~~nearly double~~ increase substantially (increase of ~~92~~ 70%).
5. The addition of vegetated 100 foot buffers along all 3<sup>rd</sup> order and larger IRW streams combined with poultry waste application cessation in the IRW would provide further reductions of P loads of between 3 and 5% compared to poultry waste application cessation alone. The addition of vegetated 100 foot buffers along all IRW streams combined with poultry waste application cessation in the IRW would provide further reductions of P loads of between 10 and 13% compared to poultry waste application cessation alone.
6. P loads to Lake Tenkiller would be more than 275,000 lbs less than current levels (less than ½ of current levels) if poultry waste had never been disposed of in the IRW. It would take approximately 100 years of cessation of poultry waste application to return P loads in the IRW to what they would have been if no poultry waste land application had occurred.
7. P loads to Lake Tenkiller since 1954 have increased at approximately ~~10,000~~ 8,000 lbs per year. Poultry waste application in the IRW is responsible for approximately ~~6,600~~ 4,700 lbs of this increase each year.
8. Poultry waste land application in the IRW is a substantial contributor (45% between 1998 and 2006 and 59% between 2003 and 2006) to P loads to Lake Tenkiller, representing the largest P source. WWTP P loads are the second largest contributor to P loads to Lake Tenkiller. Poultry plant discharges to WWTP represent a significant portion of WWTP P loads.

9. Cattle in the IRW recycle P brought into the IRW to feed poultry that is excreted by poultry and land applied to pastures within the IRW. Although the P contribution of cattle is from poultry waste, cattle accelerate the movement of P into IRW streams and rivers when they excrete waste in and near IRW streams. Six percent of P loads to Lake Tenkiller result from cattle in and near IRW streams.
10. The contributions of septic systems to P loads in the IRW are negligible.

Additional data from the IRW continue to become available. These data will be used to refine analyses reported herein and in new analyses as appropriate. Therefore, I reserve the right to update this report.